CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE
CARIBBEAN ADVANCED PROFICIENCY EXAMINATION
MAY/JUNE 2007

PHYSICS

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GENERAL COMMENTS

Unit 1

A slight increase in the candidate population returned scores similar to that in previous years. The new Paper 01 (Multiple Choice) performed well. There were four items out of 45 in which less than 30 percent of candidates gave the correct response.

The performance on Paper 02 was good except for a question on error calculation and one on refraction where the scores were very low (see detailed comments).

Unit 2

There was a large increase in the number of candidates sitting Unit 2 and the performance overall was much better than previous years.

Both Units

One weak area which stood out for the examiners, however, was in the analysis of results of experiments. It appears that candidates neither see nor do experiments in magnetism and analogue electronics and are faced with quite unfamiliar observations in the examination room to interpret questions set on these topics. The time honoured practice of candidates doing or “rotation” of labs where apparatus is more expensive has much to commend it at this level.

DETAILED COMMENTS

UNIT 1

PAPER 01

Module 1

Performance on most questions was generally satisfactory. The three lowest scoring items with only about 30 percent of the candidates giving the correct response were:

- Determining the relationship between velocity and mass for an object moved a fixed distance by a constant force $v^2 = \frac{2F}{m} x$ So $V \alpha$.
- Finding the torque of a couple.
- Understanding that an object falling at constant velocity has zero resultant force.

Module 2

There were good responses to questions on the general principles of wave-motion but two glaring weaknesses were noted: candidates did not understand two-source interference and they were unable to apply the lens formula to the formation of an image by a diverging lens.

Module 3

Plotting a graph for the variation of an empiral temperature θ with thermometric property X was beyond most candidates. The use of Stefan's Law also proved problematic. Otherwise the items in this section were not found to be difficult with one disappointing exception; when candidates were asked to find the volume of one atom of copper from given molar data, the majority of candidates instead found the volume of a mole of copper.

Unit 1

Paper 02

Section A

Question 1

The poor performance on this question (mean 2.6 out of 10) makes it obvious that candidates did not have enough practice in calculating the uncertainty in physical quantities by combining the estimated errors in measurements.

Even when candidates deduced that L was 19.2 ± 0.4 cm in part (a), often they could not say that the
–3 diameter D (= L/10) was 19.2 ± 0.4 cm. It was not surprising thereafter that combining the results to find the uncertainty in the density of the metal (part (c)) proved to be beyond most candidates.

The examiners would like to suggest that teachers of this difficult area of the syllabus, try using the method of adding the **percentage** errors in the quantities rather than the traditional method of writing an equation relating the fractional errors. Perhaps this would prove to be less confusing for the students.

For example: Percent error in D = 0.04/1.92 x 100 = 2.1%

Percent error in V = 3 x % error in D = 6.3%

Percent error in m = 0.3/30.4 x 100 = 1.0%

Percent error in density = 6.3% + 1.0% + 7.3%
and the final value for the density becomes 8.2 ± 0.6 g cm

Question 2

For most candidates this data analysis question should have been quite straight forward even if the actual experiment on cavity resonance was unfamiliar. However, two main difficulties arose:

- Candidates made plotting and reading off values hard for themselves by choosing odd scales for the graph (for example, 1:3, 1:7, etc.)
- Candidates had difficulty relating the gradient of the graph to the quantities in the given equation and so could not determine the velocity of sound (mean 5.8 out of 10).

<u>Question 3</u>

Again in this question about the determination of Young modulus. Candidates often stumbled over the connection between the gradient of a graph and the constants in the equation. The technique of using a linear graph to find a good average value of a physical quantity is commonly used in physics and practice is needed in this area.

The fact that candidates were not able, for the most part, to measure the area under the graph (part (b)) compounded their difficulties and so the mean for this question was a low 4.7 out of 10.

Section B

<u>Module 1</u>

<u>Question 4</u>

There was evidence that most candidates knew the principles involved in this question about vectors and static equilibrium but their scores were limited by their poor problem solving ability (mean 9.5 out of 20).

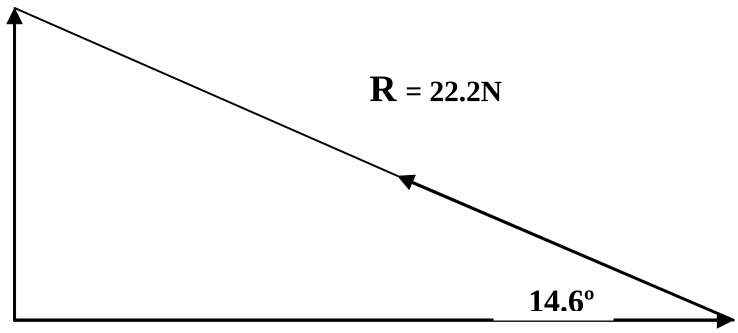
The examiners expected, at this level, that the vector addition in **part (a)** would be done by means of resolution and then addition of the components. However, attempts using scale drawings or triangles of forces were also accepted. In the latter case, candidates' trigonometry was poor and the few using this method gained much credit.

The scale drawings offered were usually much too small and even in those which were not the angles, were measured carelessly. The final values for the resultant were thus not very accurate.

Some of the better candidates drew up a table showing the relevant components and their direction (see below). This method has much to commend it in terms of clarity and avoidance of errors.

force	**x component**	**y component**
35 N	14.8	31.7
24 N	20.8	-12
20 N	-14.1	-14.1
R	+11.5	+5.6

Disappointingly a significant number of candidates, after getting the correct components, were unable to show the correct direction for the resultant. They thoughtlessly drew the remaining side of the triangle as in the diagram on the next page.



Most attempts at the standard statics problem in **part (b) (ii)** were poor even though the free body diagram was given in the question. Candidates did not seem to realize that they needed to apply the same principles they had expounded in part (i).

(a) The upward force R must be equal to the weight of 200 N

(b) The clockwise moment of P about the base of the plank would be equal to the anticlockwise moment of the weight (P x 6 = 200 x 1.5 and so P = 50 N)

(c) The horizontal forces are equal and opposite so F = P. Combining F and R yields a resultant of 206 N, 76º to the ground.

Question 5

The mean score for this question was similar to that for the alternative Question 4. Candidates demonstrated for the most part a good grasp of the concepts tested in parts (b) and (c) and scored well. It was disappointing, however, to see the number of answers in part (b) (iii) with the input power of the motor being less than its output. Surely candidates should have realised that they had the formula inverted and corrected their mistake.

In contrast the responses to part (a) (ii) were poor! Expecting candidates to know that g would not be constant over a large distance, the examiners were surprised to find instead that either gravity had been switched off (g = 0) or had been used up in providing the centripetal force.

In part (a) (iii), very few candidates were able to translate the principle that the *change* of kinetic energy was equal to the *change* of potential energy into a meaningful equation. Instead they ignored the initial kinetic energy of the roller coaster and wrote $\frac{1}{2} mv^2 = mgh$. The marks awarded in this part were consequently very low (mean 9.5 out of 20).

Module 2

Question 6

Part (a) tested candidates' knowledge of standing waves and the properties of sound. The answers were of varying quality. Some candidates had not understood that stationary waves are formed from two waves of the same type and frequency travelling in opposite directions. Perhaps if they had the opportunity to experiment with waves on strings, microwaves and sound waves in the laboratory, they might have had a better grasp of the concept. The words *subjective* and *objective* gave some candidates difficulty in part (a) (iii). The examiners were expecting candidates to associate, for example, loudness (subjective) with amplitude (objective) or pitch (subjective) with frequency (objective) etc.

Part (b) concerned intensity and intensity levels in decibels. Whilst parts (b) (i) and (ii) were answered successfully by most candidates, part (b) (iii) proved to be difficult since it required a two stage calculation – the pain threshold, 120 dB, corresponds to an intensity of 1.0 W m^{-2} and then the use of the given proportionality gives a distance of two metres from the speaker. Although the question clearly stated otherwise many candidates floundered because they assumed that they could use the *intensity level* in the proportional relationship (mean 7.3 out of 20).

Question 7

The mean score on this question was a disappointing 4.3 out of 20. This was quite a shock to the examiners since some of the content was at CSEC level and much of the remainder was merely an extension of that work. In fact the only section in which the responses were satisfactory was part (c) which contained material introduced at CAPE.

In part (a) many candidates could not define the refractive index for light waves as the ratio of the speed in the medium to the speed in a vacuum (or air), nor could they draw a diagram of wave refraction so deriving the law of refraction in part (iii) proved to be beyond them.

The use of the given law of refraction in part (b) was very poor. In fact, many candidates tripped themselves up by resorting to the (misunderstood) use of the out-moded idea of relative refractive index. The examiners would like to recommend that, to avoid such errors, teachers **always** use the law of refraction in the form given in this question: $\mathbf{n_1 \sin \theta_1 = n_2 \sin \theta_2}$.

Module 3

Question 8

Only a small proportion of candidates attempted this question rather than Question 9. Those with good mathematical skills were able to handle the exponential formula in part (b) well and score heavily on this part. However, the responses to part (a) about the use of thermometers were relatively poor (mean 3.6 out of 20).

Question 9

There was a wide spread of mediocre marks on this question (mean 7.8 out of 20).

Poor expression was the downfall of many candidates in part (a) (i). Though they knew that pressure is force/area they had difficulty relating that to collisions with walls, change of momentum, etc. as required for the kinetic theory of gases.

The application of $pV = nRT$ in part (a) (ii) proved to be challenging. It seemed that some candidates had learned the gas law at a lower level without the inclusion of the amount of gas, ($p_1V_1/T_1 = p_2V_2/T_2$) and were unable to cope with the situation where more oxygen was pumped into the cylinder. Since unlearning is often difficult, teachers might be able to prevail upon those teaching at a lower level to include the *n* factor from the start and discuss such obvious examples as pumping up car tyres and filling cylinders -

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Part (b) was about the first law of thermodynamics elicited many good responses though the usual confusion about the signs for energy added (work done ON the gas) and energy lost (work done BY the gas) frequently occurred.

UNIT 2

PAPER 01

The mean score on this paper was a commendable 64 percent and there were strong responses (with more than 80 percent of candidates correct) in various areas such as electric circuits, capacitors, digital electronics, photoelectric effect and X-rays.

The items causing the examiners concern are listed below. Perhaps teachers will be able to spend a little time straightening out these common misunderstanding with future classes.

1. A variable resistor in PARALLEL to a component will not be able to change the current through it.

2. Doubling the diameter of a wire will cause the resistance to change to a quarter of the original value if other factors are constant.

3. The r.m.s. value of an alternating current is the same as the value for the direct current which causes the same power to be dissipated.

4. A non-inverting amplifier may be easily recognised by the fact that the input goes to the positive terminal of the operational amplifier and its gain is found by adding one to the resistance ratio

   $(A = \frac{R_2}{R_1} + 1)$.

PAPER 02

Section A

Question 1

In this question candidates were provided with data to plot a graph showing the variation of the magnetic field along the axis of a solenoid. Generally the plots were good but the examiners were surprised at the substantial minority who used “dot-to-dot” rather than drawing a straight line followed by a smooth curve to show the weakening field near the end of the coil.

Part (c) was not done well. Only the better candidates recognized that the formula could only apply to the uniform field near the centre and that the field at the end was half that at the centre.

Disappointingly few candidates were able to gain the two marks in part (d) for using the formula to find the TOTAL (in capitals) number of turns in the coil (mean 4.9 out of 10).

Question 2

This question tested the use of the operational amplifier as a comparator. The principle that the op amplifier output would saturate at positive 6*V* or negative 6*V* depending on which input had the higher potential was not understood by most candidates. This led to low scores in part (b) and a mean score overall of 4.7 out of 10.

Although most candidates gained the available marks for plotting the thermistor calibration curve teachers might wish to note the following:

- Students need to be exposed to a variety of graphs in their practical work, not only linear graphs.

- They also need practice in choosing suitable scales so that the graphs are large enough without resorting to, for example, factors of three which lead to read-off difficulties.

Question 3

The response to this question were much more satisfying – many candidates scoring eight or more out of ten (Mean score 6.2 out of 10). For those scoring less, the main weakness was that they did not realise that they could read In I_o from the axis even though the scale on that axis did not start at zero: since the x-scale (absorber thickness) did begin at zero the intercept was in fact In I_o. Candidates who instead tried to calculate the value found the mathematics difficult and often failed to obtain the correct value.

Section B

Module 1

Question 4

A significant number of candidates had such inadequate understanding of electric circuits that they chose this question but could not score any marks. The mean score of 4.3 out of 20 does not therefore reflect the fact that others performed much better.

In part (a) candidates were not entirely clear on the difference between e.m.f and terminal p.d. even though they were able to define the terms. Teachers need to reinforce the idea that there is a “loss” of energy due to the internal resistance of the battery and so the energy delivered to the terminals will be less.

The majority of candidates were unfamiliar with the procedures in determining the e.m.f of a battery using a potentiometer: many could not even draw the circuit correctly.

In calculating the internal resistance of the cell in part (iv) many candidates tripped themselves up by using the e.m.f rather than the p.d. to calculate the circuit current. For many candidates at this level any voltage can be used in $V=IR$ to find the current and teachers will need, over and over again, until they get out of the habit, to emphasise to students that they must have the correct voltage across the component before calculating. (It might be noted that a similar error occurs in part (b) of Question 6)

In part (b) many candidates were unable to derive the correct set of equations using Kirchhoff’s first and second laws. Most commonly they failed to adhere to the sign conventions with regard to traversing the loops in the circuit. Even those with the correct equations were not always successful in arriving at the correct values since they were let down by their inability to solve simultaneous equations.

Question 5

The performance on this popular item was much better than that on Question 4: several candidates scored full marks and the mean of 10.3 out of 20 was better than any other question on the paper.

Marks were lost in part (a) because candidates could not define the farad and often did not understand what *dimensions* meant with reference to a capacitor (capacitance depends on the area of the plates and the distance between them).

Though part (c) was generally well done, there were many candidates who, despite their correct use of the same concepts in the derivations required for part (b), thought that each of the series capacitors had a p.d. of 6 V across them and proceeded to calculate different values for their changes. Other careless mistakes such as not inverting (1/C = ¼ therefore making the capacitance ¼ microfarad), forgetting to square V in E = ½ CV^2 and leaving out the 10^{-6} factor contributed to unnecessary loss of credit.

Module 2

Question 6

With a mean of 5.1 out of 20, the performance on this question was not very satisfactory. Many candidates had learned about the operation of a p-n junction and scored marks on part (a), but the applications of the junction diode in parts (b) and (c) were not well understood.

Part (b) required candidates to see that and L.E.D would turn ON when a p.d. exists across it, that is, when one end has a positive potential and the other is grounded. Many did not grasp this point. Those that did, failed to understand that they needed to calculate the p.d. across the resistor ($V = 15 – 2 = 13$ V) before they could use $V = IR$ to find the protective resistance used.

The responses to part (c) were even poorer with few candidates realising that the p.d. across the diode must be 0.7 V (as shown in the given characteristic) while it is conducting. Thus the peak value of the resistor's p.d. would be 0.8 V and its peak current 0.8 mA.

Since candidates generally ignored the "turn on" voltage of the diode the sketch graphs in part (c) (iii) were very poor with most candidates only gaining a mark or two for showing the general principle of rectification.

Question 7

Some candidates had obviously studied this section of digital electronics quite thoroughly and there were some excellent scores from the better candidates. However, the mean score was disappointing (6.1 out of 20) as other candidates were unable to apply their knowledge to unfamiliar situations.

In part (a), only part (ii) of this section proved to be problematic. Many candidates seemed to be unfamiliar with the use of one type of logic gate (NOR in this case) to construct the others.

In part (b), though the diagrams of flip-flops were good, the explanations of their operation as a latch were not. Similarly the deductions of the action of the triggered bistables connected as a counter (part (ii) seemed to be wild guesses rather than the use of the given principle).

The use of the operational amplifier as a summing amplifier seemed to be familiar to most candidates but many made careless errors such as missing out the input voltages of 5 V (or using one volt instead) after writing the correct formula for the circuit.
65

Module 3

Question 8

The distribution of scores on this question was unusual: either candidates performed well and scored more than 15 or their responses were poor less than four out of 20. Perhaps this reflected the fact that some were able to handle the mathematics of radioactive decay comfortably whilst others struggled to get started.

The fact that radioactive decay, is a random process, is emphasised in the teaching at the level so it is to be expected that candidates would be able to cite the evidence for this. Surprisingly even the better candidates had little idea of how to gather such evidence or how to draw conclusions from it. Descriptions of such demonstrations are included in most texts at this level and teachers, if they are unable to do the experiment in their laboratory, should at least draw these to the attention of their students.

The examiners would like to suggest that in problems such as those in part (b), the use of the half-life formula $A/A_o = 1/2^n$ rather than the exponential, often makes the solution simpler (mean 8.4 out of 20):-

For example in part (b) (iii)
12 years = 2.67 x $T_{1/2}$
so $A/A_o = 1/2^{2.67}$
Hence A = 3.9 x 10^5 Bq

<u>Question 9</u>

This question was less popular than Question 8. Some candidates seemed to be attempting it in desperation since they knew little in Module 3. How else can so many scores of zero or one be explained in a relatively straight forward photoelectric effect question? To balance this, the examiners were pleased to see that several candidates were able to score full marks (mean 6.7 out of 20).

The main loss of marks for those who made a reasonable attempt were:

- inability to find the number of photons per second from the calculated energy per second
- difficulty relating number of electrons to the current
- poor descriptions of how the kinetic energy may be obtained from the stopping potential
- careless calculations even though using the correct photoelectric equation, powers of ten being a particular difficulty
- not understanding that the wavelength must be shorter than the wavelength corresponding to the threshold frequency if electrons are to be released.